ELECTRIC TRACTION MODEL

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SYNOPSIS

In this project the historical development of railways have been traced from STEAM LOCOMOTION to ELECTRIC TRACTION with TRACTION MOTORS. A model TRACTION SYSTEM has been designed and constructed. The TRACTION MOTOR developed , runs on a 1 phase,18 volts, 50 Hz supply, through a suitable transformer . The LEVITATION has been demonstrated in the model.

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CHAPTER I

INTRODUCTION

The development of railways has always been an index for the economic growth of any country.For example Japan which is now in the economic fore front has one of the best railway systems with the fastest trains among the nations. Though the railways came into being with steam locomotives, the progress is accentuated with the introduction of electric locomotives.

There has been a rapid improvement with different systems of electric traction and much research has gone into improving the speed and the haullage capacity. Countries like Germany, United States and Japan are in the top in making great strides in developing very efficient railway systems.

With the introduction of ELECTRIC MOTORS for traction,the speed of the trains have tremendously increased,due to LEVITATION. In this project a review of the development of the various traction systems upto the mordern BULLET-TRAINS have been made. However it is sad that our country with the milage almost equal to that of Japanese railways have not yet endeavoured to mordernise its railways with LINEAR MOTORS.

An attempt has been made to highlight the use of ELECTRIC TRACTION with advantage. To illustrate the principle of operation of such a TRACTION model has been constructed and provision has been made to demonstrate the LEVITATION effect.

CHAPTER II

DEVELOPMENT OF TRAIN

In olden days the Locomotives were driven by steam engines only. Later diesel engines were developed, to drive the locomotives. Then electric locomotives were used for higher speeds, and it was more efficient. Nowadays superconducting magnets are being used for hauling the trains at larger speeds.

The following paragraphs describe the historical development of railways from steam locomotives to monorail traction.

2.1. STEAM LOCOMOTIVES :

A steam locomotive has a boiler containing water and a fire box in which coal or some other fuel is burned. The heat from the burning fuel turns the water into steam.

As the steam expands, it pushes a piston backwards and forwards inside a cylinder. The movement of the piston turns the wheels of the locomotive.

In 1804, a British Engineer, Richard Trevithick, built the first workable steam locomotive. It could pull a load of 25 tonne at 8 km/hr.

2.2. DIESEL LOCOMOTIVES :

Diesel locomotives have engines similar to those of lorries and buses. They use diesel oil as fuel. There are three kinds of Diesel locomotives : Diesel_Electric, Diesel_Mechanical and Diesel_Hydraulic. Diesel locomotives are generally not as powerful as Electric locomotives, but they do not require overhead wires or special tracks.

Japanese DF 50 Diesel Electric Locomotives are used for fast main line services. They are heavy, but easy to maintain and react quickly to their controls. In the United States, several Diesel Electric Locomotives are sometimes joined together to pull very heavy trains or to haul one over different countries.

German DC II Diesel Locomotives of the late 1920's were small but powerful. Other German Diesel Locomotives were in use as early as 1912.

2.3. ELECTRIC TRACTION :

Electric Locomotives obtain power from overhead conductors, or from a third rail placed beside the rails they run on. They are driven by Electric motors.

The first successful Electric Locomotive was built by the German firm, M/S.SIEMENS. It was demonstrated at the BERLIN Exhibition in 1879. The locomotive picked up Electric current from a third rail. It had a speed of 7 km/hr and pulled a wagon of 18 panengers.

The German locomotive, EC 40 was used in the early 1900's. To assist it on upward slopes, the locomotive was fitted with geared wheels that was connected with a teethed track on the ground.

Japanese have always been in the forefront in developing Electric Traction Models. In the year linear motors have come to have electric train.The linear motors are used, because they can obtain high speeds.

2.4. MODERN HIGH SPEED RAILWAYS :

The new TOKAIDO line in JAPAN often called "THE BULLET TRAIN" runs between TOKYO and OSAKA. It is one of the most advanced railways in the world.

It is driven by a Linear Induction Motor. It can reach a speed of 250 Km/hr. These trains run on a track of 1435 mm wider than the standard Japanese track with of 1067 mm for better stability.The trains are completely airtight. If they were not, passengers would suffer discomfort. The running of trains is controlled by a general control centre in TOKYO.

These trains are built of Aluminium body, so as to reduce the weight. The motors and brakes are more powerful than those used in earlier high speed trains.The Japanese Underground Electric train was intially tested and driven using LINEAR INDUCTION MOTOR. Again LINEAR INDUCTION MOTOR was used for a Suspension Type Mono Rail and Above The Track Mono Rail.

They have recently developed trains driven by LINEAR SYNCHRONOUS MOTORS that run on magnetic cushion. These trains reach speeds of 450 to 500 Kms/hr. Research is being done on trains that run in VACCUM, driven by LINEAR INDUCTION MOTOR or LINEAR SYNCHRONOUS MOTOR, and they can easily reach speeds of 4500 to 5000 Kms/hr.

2.5 TRACTION SYSTEMS IN INDIA:

India is by large is got the most complex railway networks in the world. Electric traction in India started with D.C. system. 600 to 750 V supply is used for urban services. For urban and main line services 1500 to 3000 V is prefered. Examples of 1500 V electrification will be found in sections from Bombay V.T to Igatpuri and Pune and Bombay to Virar. 3000 V D.C. system has been employed on Howrah - Burdwan section but this had to be converted to 25 kv. A.C. system.

Contact system in D.C. may be of third rail type or overhead conductor type. Former is however used for low voltage systems upto 750 V. Contact system is fed from substations which may be spaced 3 to 5 km for urban and sub-urban heavy traffic and 15 to 30 km. for main line services. Substations receive power by high voltage 3 phase lines. Therfore , substation consist of transformers and rotary converters or mercury arc rectifiers. These substations are automatic and are remote controlled. Main advantage of D.C. traction will be found in the series motors possesing most desired characteristics of producing heavy starting torque for given armature current and self relieving property.

D.C. series motor has smaller weight per h.p., low maintenance cost as compared with A.C series motor and is capable of attaining high acceleration and retardation rates. It is therfore better suited for urban and suburban services where frequent starting and stopping is encountered. Main disadvantage of D.C. system is high cost of substation.

2.6 CHOICE OF TRACTION SYSTEM FOR INDIA:

Apart form the relative merits of different systems of traction,the choice is also to be governed by the relative economics of transportation and the ability of indigenous fuel resources.

Annual costs of locomotives as well as operating expenses are directly propotional to the traffic density for diesel and steam traction.With electric traction the cost of fixed installations is heavy.With greater traffic densities the reccuring costs of fixed installations get spread over,thus reducing the total annual costs compared to steam and diesel traction.

As a result of study carried out on INDIAN RAILWAYS,annual reccurring costs including interests,deprecia-tion,repairs,maintenance and fuel consumption were found out or various traffic densities at diffrent fuel costs of coal,diesel oil and electrical energy.

Diesel traction is cheaper than steam traction for coal costs above Rs.45/= per tonne and diesel oil upto Rs 650/= per kilo-litre.Further that the cost of fuel on various zonal rail-ways is different,the traffic densities at which electrification is justified on different zonal railways would also be different.

So for INDIAN RAILWAYS are concerned about 72% of route kilo-meterage comprises of single line sections and average traffic density even at 1962-63 level of traffic is very much higher than that neccessary for justification of electrification of single line sections.

It should further be noted that traffic densities at which electrification would be justified on graded sections would be less.Due to the relative increase in fuel energy charges and savings in the energy effected by the adoption of REGENERATIVE BRAKING which tilts the comparison in the favour of ELECTRIC TRACTION.Regarding availability of indigenous fuel sources,it is to be noted that even through coil is produced sufficiently but in view of increased industrialisation and establishment of steel and other metallurgical industries.It could be neccessary to conserve good quality of coal.

Since indigenous production of crude oil forms a small fraction of the demand and that diesel is a major requirement of mechanized farming and defense equipment, we cannot have as much free hand in its application to transport.

Electricity can be generated from any of the natural primary sources of energy such as coal,lignite,water,uranium and thorium.Poor quality of coal with high ash content and middlings from coal washeries which cannot be transported economically over long long distance and which cannot be used for any other purpose can be best utilised in the pit head thermal generating stations.

BATTERY DRIVE:

Vehicle carries batteries which can supply the driving motors.Plying scope of the battery vehicle is limited as batterys require charging after frequent intervals.These are therefore employed for local delivery of goods in large towns with maximum daily run of 45 to 60 km,shuntting and traction in industrial works.Special province of application of battery drive is in mines.Mine regulation provide for the use of trolley wire locomotives specially in gassy mines under following conditions:

1.The roadways are properly ventilated with minimum air velocity of 1 m/s.

2.Roadways have methane content not more than 0.3 %.

3.The roadways do not happen to be within the zone of mining influence.

CHAPTER III

CONSTRUCTION DETAILS

To construct the model of Electric Traction, the following steps are undertaken:

1. The construction of track
2. Provision for feeding the rail
3. Supply for traction
4. Magnetic System for levitation

A closed track is formed in an oval shape, mounted on supporting pillars. The track consists of two L - channels bent in oval shape and brazed at the centre. Centrally to the track is laid a circular copper conductor of 16 SWG insulated from the track. This will serve as one of the following points in the construction of the traction motor.

The supply to the traction motor can be from 18 volts A.C. or D.C. The terminals are connected between the track and the copper feeding point between the track. The motor gets the supply by the contacts made, one between the track and the wheel and the other between the copper conductor and special contacts which will press against the central copper rails. An autotransformer is being used to get the required voltage for traction.

A levitation system may be REPULSION TYPE or ATTRACTION TYPE. Levitation in the attraction model is being demonstrated using ATTRACTION TYPE. The magnets used here are of STRONTIUM FERRITE material. This magnetic material has the ability to attract and lift a weight of 4.5 to 5 kg. During levitation, the amount of force and current required becomes high. The lift is being demonstrated for 2 to 3 mm height. The traction system has been tested, with voltage varying from 0 to 18 volts. For reversal, provision has been made using an additional winding.

CHAPTER IV

CHARCTERISTICS AND FEATURES

Since field flux and armature current both change simultaneously,their product is always positive even if both parameters individually may be neagative.Therefore torque produced by SERIES MOTOR is in the same direction for each half cycle of tyhe alternating current.In case of D.C SERIES MOTOR the torque produced is uniform,whereas in the case of A.C SERIES MOTOR the torque produced is pulsating.If,however,the construction of 1 phase SERIES MOTOR were same as D.C SERIES MOTOR,we will encounter unusual performance on following accounts.

1.Alternating field flux would give rise to heavy eddy losses in the field and yoke.This will increase motor heating and reduce operating efficiency.

2.If the motor is operaating usin D.C. supply it would produce rotational e.m.f in conductors due to armature reaction flux along brush axis.Self induced e.m.f often called REACTANCE VOLTAGE is produced in these conductors due to the reversal of current in them on crossing the brush axis.In the case of 1 phase SERIES MOTORS,in addition to rotational e.m.f and REACTANCE VOLTAGE transformer e.m.f is also produced which will be maximum for conductors because their plane is perpendicular to the axis of main poles.Brushes,short circuiting these coils having transformer induced e.m.f. , would produce heavy sparking .

3.The power factor of the motor will be very poor.

4.For given torque to be produced, speed on A.c supply will be lower than that on D.C. supply.In other words output on A.C supply will be lower than on D.C supply.

Since field flux remains constant,reduction in e.m.f.,in case of A.C. SERIES MOTOR would suggest that the speed of A.C.SERIES MOTOR for given developed torque is less than that of D.C.SERIES MOTOR.In other words output of A.C. SERIES MOTOR will be less than that of D.C.SERIES MOTOR.

Speed-Torque characterstics for A.C and D.C SERIES MOTORS gives the whole performance revolves in the point that back e.m.f. in A.C.SERIES MOTOR should be made as far as possible equal to the back e.m.f in D.C. SERIES MOTOR.This would mean that the value of armature and field reactances should be made very small.

We can reduce field reactance by employing less number of turns on the field.This will in turn reduce field flux.In order tyo develop same torque we have to increase turns on the armature in the same ratio.This would reduce the field reactance and would produce more armature reactance.Since it is easy to cancel the reactance of armature by providing compensating winding,this transfer of reactance from field to armature will be in order.

CONSTRUCTIONAL FEATURES:

From the above disscussions,we will summarise the constructional features of A.C.SERIES MOTOR as follows:

1.It has comparatively less number of turns on the field and more number of turns on the armature.Number of armature turns in any circuit is reduced by employing lap wound armatures and using large number of poles specially for traction motors.This condition therefore makes these machines for low voltage operation only say 300 to 400 volts.

2.Whole of the magnetic circuit of the motor has to be built up from insulated sheet steel stampings.In big traction motors laminated stator is supported in main solid motor frame which does not carry any magnetic flux.Because of large number of poles to be provided,many designs of the motors do not have salient poles but instead slots are cut axially into the inner face of the stator to accomodate the main commutating and compensating winding.

3.It has compensating winding.Its main function is to cancel out the magnetic effect of armature current.

4.Since field is weak,it has small air gap.

5.To reduce transformer e.m.f which is the source of commutation troubles, these motors are run prefferbly 16.66 or 25 cycles supply.

6.To reduce sparking brush width is kept small.

7.These motors are suitable for maximum voltage upto 400 volts.These motors,therefore,require transformer in case high voltage supply is available.

8.For given h.p,A.C SERIES MOTOR weighs 1.5 to 2 times the corresponding D.C.SERIES MOTOR.

9.Industrial frequency series motors employ low flux density.Speed-Torque charcacterstics as a result of this becomes steeper.As a consequence of this motor needs fewer voltage steps for starting.

10.Due to steeper speed-torque characterstic load division between different motors of a vehicle is less affected by wear and tear of wheel tyres.

USES:

Due to poor power factor at starting,A.C.SERIES MOTOR has poor starting torque.As such these motors are not suitable for urban and sub-urban traction services where high acceleration is required.However for main line service,single phase motors are extensively used.

CHAPTER V

LINEAR MACHINES

A Linear motor can be regarded as a normal rotating motor cut and opened out flat.Of the two elements derived respectively from the stator and rotor, either may move. The member connected to the supply is called the primary,and other the secondary. Either the member is fixed as the stator, while the rotor becomes the movable runner.

The idea of associating power conversion with LINEAR MACHINES dates back to the early 1830s. FARDAY attempted to generate electricity by utilising the streaming water of the river THAMES as the active conductor, the geomagnetic field as the field excitation and dowgling wires as the electrodes.

The high speed applications of LINEAR ELECTRIC MOTORS are mainly Propulsion and Levitation systems for High Speed Ground Transportation. Rotary motors are a poor choice for use at speeds above 250 km/hr because of adhesion and other mechanical considerations. For speeds at which mechanical contact is undesirable, it has been proposed to use a Levitation Machine for a Magnetic Suspension System.

weight and volume are important considerations in the choice and design of Linear Motors. The Power Factor has a major impact on the power conditioning sub system.

5.1. MAIN PURPOSE OF SELECTING LINEAR MOTORS:

Linear Motors can be used for Low Speed and Stand Still Applications. But LINEAR INDUCTION MOTOR used for High Speed Applications, contains a shorted primary. The other purposes are:

1. High acceleration and deceleration.
2. Less wear on wheels where acceleration & deceleration takes place.
3. Easy speed control.
4. Easy maintenance, repair and replacement .
5. Mechanical and Electrical protection.
6. Ability to withstand a hostile environment .
7. Existance of normal force, which is advantageous in Levitation Machines.

5.2. STATE OF ART TODAY :

In the modern world where time is an important factor, we still cannot depend on steam and diesel engines. Nowadays engines are designed to reach speeds of around 300 to 400 km/hr.

In Japan, the BULLET TRAIN attains speeds of 300 km/hr. The weight of the train is comparatively very light. It uses automatic braking which is an important advantage in High Speed Trains.

To avoid road traffic , Overhead Suspension Type Monorails, Above Track Monorails, Underground trains are being used. The MONTREAL UNDERGROUND in Canada is one of the most modern in the world. The trains here use the Pneumatic Tyred Wheels. In Tokyo Underground Systems, the trains are Aluminium bodied and have elevated tracks.

The very recent applications in Linear Motors are explicit in Japan. They are "NO WHEEL" run vehicles. They run in Super Conductive Magnetic Cushion. They reach speeds of 500 km / hr. Research is going on to run trains in VACCUM. In these conditions the trains can easily reach speeds of 4500 to 5000 kms/hr.

5.3. ADVANTAGES OF LINEAR MOTOR :

1. The existance of normal force is advantageous for Levitation.
2. Speed control is easy.
3. Less maintenance.
4. Size of machine can be reduced by an apt design.
5. High speed applications can be performed.

6. Can be used for Propulsion and Air Cushion Rail Applications.

7. High efficiency.

In general, for high speed Ground Transport, the large power requirements make it obvious that high efficiency, power-factors and voltage as well as low specific weight and volume are important advantages in choice and design of LINEAR INDUCTION MACHINES.

5.4. LINEAR MOTOR APPLICATIONS:

Linear Motor applications can be mainly divided into:

1. High speed applications
2. Low speed and stand still applications.

HIGH SPEED APPLICATIONS:

(1) PROPULSION (2) LEVITATION systems for High Speed Ground Transport (HSGT). For speeds above 250 km/hr. Linear Motors are very efficient because of adhesion and other mechanical considerations. For High Speed Applications, LINEAR INDUCTION MACHINES have short primary on the vehicle and the secondary being the rail.

LOW SPEED APPLICATIONS :

In low speed applications, a Single Sided LIM (SLIM) is by for the most extensentively used. The SLIMS are used for :

(1) Handling of parts in processing of sheet metals.

(2) Tensioning of an aluminium strip for coiling.

(3) Linear Disk Motor for achieving traction for overhead crane.

(4) Linear Disk Motors can also be used for ship propulsion.

(5) Flat Linear Motor is used as an Automatic door operator.

(6) LIM can serve for pipe lifting beam in steel works.

(7) Tubular LIM (TLIM) can be used as actuators in mechanical handling.

Though the number of applications are more in Low Speed Applications, LIM's are also importantly used for High Speed Traction Applications extensively.

CHAPTER VI

CONCLUSION

Growth of railways and industrialisation have much correlation.Japan owes its economic superiority to one of the most important parameters namely an efficient railway system.They have done much research in improving the speed and capacity through these years.In the early 70's the LINEAR ELECTRIC MOTORS have been put to use for TRACTION,thus increasing the speed of locomotives from 140 to 230 km/hr. Since then, tremendous improvement in MAGNETIC TRACTION has been seen and this has resulted in LINEAR SYNCHRONOUS MOTORS and LINEAR INDUCTION MOTORS with the speed of 400 to 500 kms/hr.

A model TRACTION system with UNIVERSAL TRACTION MOTOR has been designed and constructed , and is operative.It is a 1 phase MOTOR operating from 18 volts, 50 Hz A.C / D.C supply. The speed can be varied by voltage control.The motor has 60 watt capacity operating at a power factor of 0.7(lag).Provision has been made to illustrate the principle of LEVITATION using STRONTIUM FERRITE permanent magnets.This model has an energised single conductor between the rails as in the case of CW-40 MONO RAIL system in Japan.

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